

WHAT IS CLAIMED IS:

- 1 1. A method of determining whether a multi-component target system meets a given
2 multi-part performability requirement, the method comprising:
3 operating on a representation of the target system, providing a first failure-
4 scenario analysis of said target system,
5 generating a multi-part performability function of said target system using said
6 first failure-scenario analysis,
7 comparing said multi-part performability function with said multi-part
8 performability requirement, and
9 determining from said comparing whether said target system meets said multi-
10 part performability requirement.

- 1 2. The method as set forth in claim 1, the step of comparing further comprising:
2 calculating if said first failure-scenario analysis provides sufficient data for
3 generating a multi-part performability function determinative of target system
4 performance capability when compared to said multi-part performability requirements,
5 and
6 if so, proceeding with said step of determining, or
7 if not, providing a second failure-scenario analysis of said target system; and
8 repeating said steps of generating, comparing, and calculating until a next failure-
9 scenario analysis provides sufficient data for generating a multi-part performability
10 function determining said target system performance capability when compared to said
11 multi-part performability requirements.

- 1 3. The method as set forth in claim 1, wherein said multi-part performability
2 requirements are represented as one or more performance levels versus percentage of
3 time at each of said performance levels.

- 1 4. The method as set forth in claim 3, wherein the step of generating a multi-part
2 performability function comprises:

3 creating a multi-part performability curve as one or more performance levels
4 versus percentage of time at each of said performance levels.

1 5. The method as set forth in claim 1, the step of operating on a representation of the
2 target system comprising:

3 synthesizing a model of the target system based on predetermined individual
4 components of the target system wherein each of said components has a characteristic
5 failure specification.

1 6. The method as set forth in claim 5, further comprising the steps of:
2 combining one or more said components as a macro-component;
3 computing the failure probability of the macro-component as a function of the
4 failure probabilities of its respective one or more components; and
5 using macro-components in said failure-scenario analysis.

1 7. The method as set forth in claim 1, wherein the step of providing a first failure-
2 scenario analysis of said target system comprises performing a failure-scenario analysis
3 in accordance with the further steps of:

4 let "FP(c)" denote a probability that a system component "c" of the target system
5 will fail; then,

6 (1) Let "D" represent a failure-free system;
7 (2) Let "c₁, c₂. . .c_{mf}" be components that can fail independently in D;
8 (3) Let "sf" be the number of concurrent failures being considered in the
9 last invocation (initially 0);
10 (4) Let "s" be the ordinal number, among the scenarios with exactly "sf"
11 failures, of the scenario returned in the last invocation (initially 0);
12 (5) If there exist exactly "s" scenarios with "sf" concurrent failures, then sf
13 = sf+1; s = 0;
14 (6) If sf ≤ mf, then s = s+1, otherwise exit;
15 (7) choose a₁, a₂. . .a_{sf} (where a_i, i=1, . . . sf are different integers
16 between 1 and mf) such that there are exactly "s-1" scenarios with "sf"

17 concurrent failures more likely to occur than $c_{a1}, c_{a2} \dots c_{asf}$;
18 (8) set $sc = D$ with components $c_{a1}, c_{a2} \dots c_{asf}$ marked as failed;
19 (9) set $p = FP(c_{a1}) \times FP(c_{a2}) \times \dots \times FP(c_{a(sf)}) \times (1-FP(c_{bl})) \times \dots \times (1-$
20 $FB(c_{b(mf-sf)}))$, where $c_{bl}, \dots c_{b(mf-sf)}$ are all the components that did not fail
21 in "sc"; and
22 (10) return (sc,p).

1 8. The method as set forth in claim 1, the step of providing a first failure-scenario
2 analysis of said target system further comprising:

3 eliminating analysis of all failure-scenarios wherein said target system is non-
4 functional in accordance with said multi-part performability requirement, and

5 eliminating analysis of all failure-scenarios wherein said target system is fully
6 functional in accordance with said multi-part performability requirement.

1 9. The method as set forth in claim 8, the step of generating a multi-part
2 performability function comprising further steps of:

3 entering a multi-part performability function indicative of all failure-scenarios
4 wherein said target system is non-functional; and

5 entering a multi-part performability function indicative of all failure-scenarios
6 wherein said target system is fully functional in accordance with said multi-part
7 performability requirements.

1 10. The method as set forth in claim 1, the step of providing a first failure-scenario
2 analysis of said target system comprising:

3 failure-scenarios are repetitively entered based on an order beginning with a most
4 likely failure-scenario.

1 11. The method as set forth in claim 10, comprising the steps of:

2 if a multiplicity of like components having like failure probability and effect are
3 employed within said target system, treating said multiplicity of like components as a
4 single component of said target system.

1 12. The method as set forth in claim 1, further comprising:
2 verifying an equation for a predetermined target system and given multi-part
3 performability requirements:

4

5
$$M$$

6
$$\sum_{k=1}^i OP(S_k) 1(U(S_k) \geq r_j) \geq f_i, \text{ for } j=1, \dots, n$$

7

8

9 where "j" is a failure-scenario among failure-scenarios with "i" failures, returned
10 in the last invocation, and performance of the target system is at least r_j with probability
11 f_j , or greater, for each given pair (r_j, f_j) .

1 13. The method as set forth in claim 12, the step of verifying the equation further
2 comprising:

3

4 (1) set $i = 1$;
5 (2) generate the next state S_i and its occurrence probability
6 $OP(S_i)$, from said step of generating the next failure scenario;
7 (3) compute $U(S_i)$ using a performance predictor; and
8 (4) if,

9
$$\sum_{k=1}^i OP(S_k) 1(U(S_k) \geq r_j) \geq f_i, \text{ for all } j=1,2, \dots, n,$$

10
11

12 then the target system is capable of fulfilling the multi-part
13 performability requirements, exit and report; or

14 (5) if,

15
$$\sum_{k=1}^i OP(S_k) 1(U(S_k) < r_j) \geq 1-f_i, \text{ for any } j=1,2, \dots, n,$$

16
17

18 then the target system fails the multi-part performability
19 requirements, exit and report; and otherwise,
20

(6) set $i = i + 1$ and go to step (2).

1 14. A computer memory comprising:
2 computer code operating on a representation of the target system, providing a
3 first failure-scenario analysis of said target system;
4 computer code providing a first failure-scenario analysis of said target system;
5 computer code generating a multi-part performability function using said first
6 failure-scenario analysis;
7 computer code comparing said multi-part performability function with said
8 multipart performability requirements; and
9 computer code determining from said comparing whether said target system has a
10 capability of performing said multi-part performability requirements.

1 15. The memory as set forth in claim 14, the computer code comparing further
2 comprising computer code:
3 calculating if said first failure-scenario analysis provides sufficient data for
4 generating a multi-part performability first function determinative of predicting multi-
5 part performability when compared to said multi-part performability requirements, and
6 if so, proceeding with said step of determining; or
7 if not,
8 providing a second failure-scenario analysis of said target system;
9 repeating by generating a multi-part performability next function;
10 comparing said next function with said multi-part performability
11 requirement; and
12 calculating until a next failure-scenario analysis provides sufficient data
13 for generating a multi-part performability second function determinative of
14 predicting multi-part performability of said system when compared to said
15 multi-part performability requirements.

1 16. The memory set forth in claim 15, the computer code providing a first failure-
2 scenario analysis of said target system further comprising:
3 eliminating all failure-scenarios wherein said target system is non-functional; and

4 eliminating all failure-scenarios wherein said target system is fully functional in
5 accordance with said performance requirements.

1 17. The memory as set forth in claim 16, the code providing a first failure-scenario
2 analysis of said target system further comprising:

3 failure-scenarios are repetitively entered based on an order beginning with a most
4 likely failure-scenario.

1 18. A method of doing business of verifying performability of a target system having
2 predetermined components and predetermined multi-part performability requirements,
3 the method comprising: using a computer,

4 (1) operating on a representation of the target system, including providing a
5 failure-scenario analysis of said target system;

6 (2) generating a multi-part performability curve using said failure-scenario
7 analysis;

8 (3) comparing said requirements with said curve ;

9 (4) determining from said comparing whether said target system has the capability
10 of performing said multi-part performability requirements; and

11 (5) generating a report indicating of results whether said target system has the
12 capability of performing said multi-part performability requirements.

1 19. The method of doing business as set forth in claim 18 further comprising:

2 calculating if a first failure-scenario analysis provides sufficient data for
3 generating a multi-part performability curve determinative of whether said multi-part
4 performability requirements are satisfied; and

5 if so, proceeding with said step of determining, or

6 if not,

7 providing a second failure-scenario analysis of said target system;

8 repeating the processes of generating a multi-part performability curve;

9 comparing said requirements with said curve; and

10 calculating until a next failure-scenario analysis provides sufficient data

11 for generating a report predicting multi-part performability of the target system
12 with respect to said requirements.

1 20. The method as set forth in claim 19, the step of providing a first failure-scenario
2 analysis of said target system comprising:
3 failure-scenarios are repetitively entered based on an order beginning with a most
4 likely failure-scenario.

21. A method of reporting performability of a given data storage system under a
given system performance requirements specification, the method comprising:
 generating a plurality of failure scenarios indicative of individual component
failures;
5 determining performance states of said system under each of said failure
scenarios;
 comparing a function indicative of said performance states to said system
performance requirements specification; and
 based on a comparison derived from said step of comparing, reporting whether
10 the performability of the given system meets the given system performance requirements
specification